

Original Article

Body composition of elite youth soccer players with respect to field position

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Abstract:

The aim of the study was to determine and compare selected body composition variables from the field position perspective in elite youth soccer players. The research sample consisted of three youth elite soccer teams of U19 category. Totally, 73 soccer players (age = 18.7 ± 0.3 years) were divided according to their field positions into: goalkeepers (n = 7), defenders (n = 24), midfielders (n = 31) and attackers (n = 11). Following parameters were observed: Lean body mass (LBM), percentage of Fat Mass (FM), Body Cell Mass (BCM) and Extra Cellular Mass (ECM) and their mutual ratio (ECM/BCM) as well as segmental proportion of muscle mass. Multilevel analysis of variance revealed significant differences in means of the selected parameters between the observed groups (field positions) ($F_{(30,186)} = 3.01, \lambda = 0.29, p < 0.01, \eta^2 = 0.33$). Analysis of variance showed a significant effect of the following parameters: body mass $F_{(3,73)} = 6.29, p < 0.01, \eta^2 = 0.21$, lean body mass: $F_{(3,73)} = 11.65, p < 0.01, \eta^2 = 0.34$, segmental muscle mass distribution for right leg $F_{(3,73)} = 6.09, p < 0.01, \eta^2 = 0.21$, left leg $F_{(3,73)} = 8.35, p < 0.01, \eta^2 = 0.27$, right arm $F_{(3,73)} = 9.07, p < 0.01, \eta^2 = 0.28$ and left arm $F_{(3,73)} = 8.11, p < 0.01, \eta^2 = 0.26$. Goalkeepers significantly differed from defenders and midfielders in body weight and achieved significantly greater proportion in segmental distribution of muscle mass in all limbs in comparison to the other field positions. Research has shown differences between anthropometric indicators and body composition parameters in players on the basis of division according to their field positions.

Key words: football, fat mass, lean body mass, testing, performance

Introduction

Body composition is an important indicator of physical fitness and general health of athletes (Warner, Fornetti, Jallo, & Pivarnik, 2004) and nowadays it also is a frequently discussed topic in scientific literature. Optimal body composition in terms of health is individual and is always determined by age, gender, somatotype, genetic factors, level of physical activity and individual variability. In athletes, body composition is not only considered a prerequisite for health but it also firmly fits in the structure of sport performance and together with other factors determines the quality of human motion and the final level of performance. Body composition provides us with an athlete's detailed physiological profile. Amount of lean body mass determines values of individual parameters of functional fitness. It is difficult to define optimal body composition for a particular sport discipline. Generally, inactive fat mass is undesirable and active muscle mass is desirable for physical activity. Excess adipose tissue acts as dead weight in activities during which the body mass must be repeatedly lifted against gravity during locomotion and jumping (Reilly, 1996); this in turn decreases performance and increases the energy demands of the activity. In contrast, fat-free mass contributes to the production of power during high-intensity activities and provides greater absolute strength for resistance to high dynamic and static loads. Body composition is a key consideration in the physical make – up of professional soccer players in terms of that one of aims of body composition assessment is to differentiate and quantify different body compartments (Sutton, Scott, Wallace, & Reilly, 2009); on the other hand, it also detects symmetry of active mass distribution in individual segments as injury prevention (Malá, Malý, Zahálka, & Bunc, 2014). Information on body composition can be an indicator of athlete's nutritional state; moreover, it can provide information on current body fluid homeostasis (Andreoli et al., 2003). Assessment of intracellular and extracellular mass belongs to the best predictors of muscular efficiency that can predict physical performance (Andreoli et al., 2003). Elite soccer players are characterised by relative heterogeneity in body composition. However, different demands on particular field positions are also reflected in different body composition of these players. In elite soccer, differences between physiological parameters and anthropometric predispositions in relation to the player's field position were found. Aerobic requirements are greatest in outfield players and midfield players, and least in central defenders (Reilly & Thomas, 1976). Team position is of extreme importance in interpretation of morphological data because there are specific demands for a specific play position (Matkovic et al., 2003). Bioelectrical impedance analysis is in practice commonly used for its advantages, such as inexpensive, non-invasive, portable, quick, safety of operation, neither requires a high degree of technical skill nor client's discomfort as it is in hydrodensitometry. Nowadays, there are also studies observing changes in body

composition in elite athletes during the match, during sports training periods and the effect of supplements, as well. Houtkooper, Lohman, Going, and Howell (1996) reported that in case of proper standardization of methods, instrumentation, and subject preparation, this non-invasive body composition assessment approach can quickly, easily, and relatively inexpensively provide accurate and reliable estimates of fat free mass and total body water in subjects.

The aim of the study was to determine and compare selected body composition variables from the field position perspective in elite youth soccer players using bioelectrical impedance analysis.

Material & methods

Participants

The research sample consisted of three youth elite soccer teams of U19 category (participants of the highest national league). Totally, 73 soccer players (age = 18.7 ± 0.3 years) were divided according to their field positions into: goalkeepers (G, $n = 7$), defenders (D, $n = 24$), midfielders (M, $n = 31$) and attackers (A, $n = 11$). All participants had at least a 9 year soccer career and performed at least 5 training sessions and 1 match during a week. Participants recruited were not injured or rehabilitating from injury at time of testing.

Methods of data collecting and processing

Data identifying body composition of the players were recorded under the same conditions in the morning between 8:00 – 10:00^{AM}. Body composition was measured using the bioimpedance method under the standard conditions described in the BIA guidelines (Kyle et al., 2004b). In the 24 hours prior to the measurements, the participants did not consume any medications (including alcohol and caffeine) or pharmacological agents that could influence the results of the measurement. They were also told not to eat or drink before the measurement and to maintain good hydration and a normal routine. Furthermore, the athletes did not perform high intensity physical activity of any significant duration for the 48 hours before the tests. Before the measurement, we measured the participants' current body weight using an electronic scale with accuracy of 0.1 kg (Soehnle ©, Germany) and body height in standing position to the nearest 1mm by anthropometric device (SECA220©, Hamburg, Germany). To determine the whole body bioimpedance, we used BIA 2000 M device (Data Input GmbH, Frankfurt/Main, Germany). The measurement was carried out using tetra-polar electrodes which were placed on the limbs on the same side of the body. Electrodes were placed in the middle of metacarpal bones and wrist and metatarsal bones and the ankle. Following parameters were observed: Lean body mass (LBM), percentage of Fat Mass (FM), Body Cell Mass (BCM) and Extra Cellular Mass (ECM) and their mutual ratio (ECM/BCM). The segmental proportion of muscle mass was assessed from parameters obtained by the multi-frequency bioimpedance method using a Tanita MC-980MA device (Tanita Corporation, Japan). This device uses 8-point electrodes and works on 6 frequencies (1, 5, 50, 250, 500 and 1000 kHz). We focused on parameters related to proportion of muscle mass on paired limbs – preferred or non-preferred arm (PA or NA) and preferred or non-preferred leg (PL or NL).

The participants received a verbal description of the procedures before testing and completed a written informed consent that was approved by the ethical committee of Faculty of Physical Education and Sport, Charles University in Prague. Measurements were performed according to the ethical standards of the Helsinki Declaration and the ethical standards in sport and exercise science research described by Harriss and Atkinson (2011).

Statistical analysis

The results were expressed in absolute values and percentages and the evaluation was made with the use of basic statistical characteristics (Arithmetic Mean, Standard Deviation). To investigate the main effect of the differences between the monitored variables among the players based on their field positions, we used Multilevel analysis of variance (MANOVA). To discover significant differences between the observed field positions, analysis of variance was used (ANOVA). In cases of significance between groups, we used Bonferroni's posthoc test. When the criterion of sphericity, as one of the conditions of ANOVA, which was assessed using the Mauchly's test (χ^2), was not met, degrees of freedom were adjusted by means of Greenhouse-Geisser's (GG) sphericity correction and then the statistical significance was assessed according to particular degrees of freedom. The probability of type I error (alpha) was set at 0.05 in all statistical analyses. The probability of type II error (beta) was controlled using *posthoc* (retrospective) analysis and it was set at 0.2 (conventional value). Effect size was assessed using the „Partial Eta Square” coefficient (η_p^2), which explains the proportion of variance of the monitored factor. The comparison of segmental muscle mass distribution between limbs was carried out using the Student's t-test for dependent variables which was preceded by analysis of variance identity based on an F-test. Statistical analysis was performed using IBM® SPSS® v21 (Statistical Package for Social Science, Inc., Chicago, IL, 2012).

Results

Multilevel Analysis of Variance revealed significant differences in means of the selected parameters between the observed groups (field positions) ($F_{(30.186)} = 3.01$, $\lambda = 0.29$, $p < 0.01$, $\eta_p^2 = 0.33$). Average values of the selected body composition variables and their variability in individual groups are presented in Table 1.

Table 1. Descriptive statistics of observed variables in soccer players with respect to field position

Field position	Goalkeepers		Defenders		Midfielders		Attackers	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Body height (cm)	190.51	6.98	177.02	5.67	174.19	29.46	180.62	5.64
Body mass (kg)	84.33	4.52	67.48	14.27	71.64	5.43	75.60	7.28
ECM/BCM	0.75	0.07	0.71	0.06	0.72	0.05	0.74	0.06
Fat mass (%)	11.24	1.65	10.14	1.92	10.04	1.62	10.97	2.05
LBM (kg)	74.94	4.34	63.35	5.44	64.38	4.18	67.15	5.23
Right leg (kg)	12.44	1.01	10.71	0.93	10.82	0.89	11.07	1.29
Left leg (kg)	12.36	0.99	10.30	0.94	10.46	0.89	10.81	1.34
Trunk (kg)	35.51	4.25	31.95	2.87	32.38	2.42	33.94	2.88
Right arm (kg)	4.67	0.48	3.40	0.52	3.52	0.60	3.55	0.70
Left arm (kg)	4.54	0.38	3.43	0.52	3.50	0.53	3.61	0.71

Legend: ECM/BCM – ratio of extracellular and intracellular mass; LBM – lean body mass

Analysis of variance showed a significant effect of the following parameters: body mass $F_{(3.73)} = 6.29$, $p < 0.01$, $\eta_p^2 = 0.21$, lean body mass: $F_{(3.73)} = 11.65$, $p < 0.01$, $\eta_p^2 = 0.34$, segmental muscle mass distribution for right leg $F_{(3.73)} = 6.09$, $p < 0.01$, $\eta_p^2 = 0.21$, left leg $F_{(3.73)} = 8.35$, $p < 0.01$, $\eta_p^2 = 0.27$, right arm $F_{(3.73)} = 9.07$, $p < 0.01$, $\eta_p^2 = 0.28$ and left arm $F_{(3.73)} = 8.11$, $p < 0.01$, $\eta_p^2 = 0.26$. Concerning the rest of monitored parameters, we did not record any significant differences based on the criterion of the field position (Table 2).

Table 2. Analysis of variance in observed variables. Tests of between subject effects with respect to field position of soccer players

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Body height (cm)	1636.58	3	545.53	1.37	0.26	0.06
Body mass (kg)	1700.55	3	566.85	6.29	0.00	0.21
ECM/BCM	0.01	3	0.00	0.82	0.49	0.03
Fat mass (%)	13.80	3	4.6	1.43	0.24	0.06
LBM (kg)	804.66	3	268.22	11.65	0.00	0.34
Right leg (kg)	17.68	3	5.89	6.09	0.00	0.21
Left leg (kg)	24.61	3	8.20	8.35	0.00	0.27
Trunk (kg)	30.55	3	10.18	0.63	0.60	0.03
Right arm (kg)	9.25	3	3.08	9.07	0.00	0.28
Left arm (kg)	7.23	3	2.41	8.11	0.00	0.26
Error		69	396.90			
Total		73				

Legend: ECM/BCM – ratio of extracellular and intracellular mass; LBM – lean body mass

Table 3 presents results of the multilevel comparison of groups' means on the basis of players' classification according to field positions. While field players did not show any significant differences among themselves, goalkeepers significantly differed from defenders and midfielders in body weight. Moreover, goalkeepers achieved significantly greater proportion in segmental distribution of muscle mass in all limbs in comparison to the other field positions (Table 3).

Table 3. Post-hoc Bonferroni tests in observed groups

Field position	Goalkeepers	Defenders	Midfielders	Attackers
	1	2	3	4
Body height (cm)	N.S.	N.S.	N.S.	N.S.
Body mass (kg)	2, 3	1	1	N.S.
ECM/BCM	N.S.	N.S.	N.S.	N.S.
Fat mass (%)	N.S.	N.S.	N.S.	N.S.
LBM (kg)	2, 3, 4	1	1	1
Right leg (kg)	2, 3, 4	1	1	1
Left leg (kg)	2, 3, 4	1	1	1
Trunk (kg)	2	1.	N.S.	N.S.
Right arm (kg)	2, 3, 4	1	1	1
Left arm (kg)	2, 3, 4	1	1	1

Legend: ECM/BCM – ratio of extracellular and intracellular mass; LBM – lean body mass; N.S. –non-significant differences between observed groups

Table 4 Paired differences between lower and upper extremities in observed groups

Source	Paired Differences					<i>t</i>	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval			
				Lower	Upper		
Goalkeepers – legs	0.09	0.09	0.03	0.00	0.17	2.52	0.05
Goalkeepers – arms	5.66	14.62	5.52	-7.86	19.17	1.02	0.35
Defenders – legs	0.40	0.17	0.04	0.33	0.48	11.44	0.00
Defenders – arms	-0.03	0.08	0.02	-0.07	0.00	-2.14	0.04
Midfielders – legs	0.35	0.17	0.03	0.29	0.41	11.86	0.00
Midfielders – arms	0.02	0.13	0.02	-0.03	0.07	0.94	0.35
Attackers – legs	0.26	0.16	0.05	0.15	0.37	5.37	0.00
Attackers – arms	-0.06	0.07	0.02	-0.11	-0.02	-3.13	0.01

Legend: *t* – value of testing criterion in *t*-test; Sig. (2-tailed) – significance

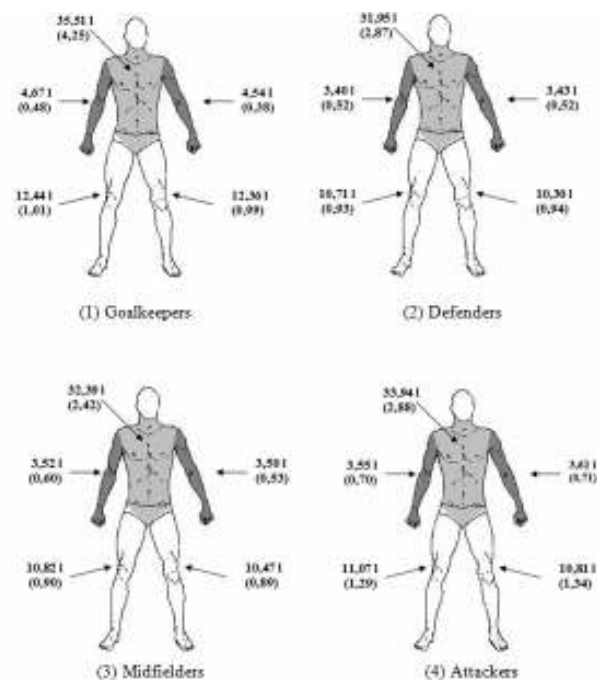


Fig. 1. Segmental muscle mass distribution for soccer players with respect to field position

Discussion

It is obvious that players in different positions have different physical and physiological profiles. There is a strong correlation between body composition, aerobic fitness, anaerobic power and positional roles in elite soccer players (Sporis, Jukic, Ostojic, & Milanovic, 2009). This study provides the comparison of the level of body composition among the positional roles in top-level soccer players.

The greatest body weight and body height was recorded in goalkeepers. A significant difference was found, however, only in body weight, when goalkeepers had significantly greater body weight than defenders and midfielders (Table 3). The collected data are in accordance with Sporis et al. (2009), who reported significantly greater body weight as well as body height in goalkeepers in comparison to midfielders in the 1st team of English Premier League and in U18 ($n = 75$, 3 teams of English Premier League). According to the authors, goalkeepers and defenders were significantly taller than midfielders and strikers ($p \leq 0.05$). According to Sporis et al. (2009), goalkeepers are the tallest and the heaviest players in the team. The consistent statements are also presented in other available studies (Boone, Vaeyens, Steyaert, Vanden Bossche, & Bourgois, 2012; Deprez et al., 2015; Di Salvo et al., 2007; Perroni, Vetrano, Camolese, Guidetti, & Baldari, 2015). Especially prediction of body height and body weight followed by estimation of lean body mass and muscle mass are used as one of determining parameters when choosing player's field position or in identification of talented children and youths for the specific field position.

Lean body mass strongly contributes to strength and power performance (Milanese, Cavedon, Corradini, De Vita, & Zancanaro, 2015). Concerning this parameter, we recorded significantly higher proportion in goalkeepers than in midfielders, defenders and attackers (Table 2). However, the limit is the comparison of absolute values, not taking body weight into account. Therefore, an interesting value of lean body mass appeared in attackers (Table 1), when significance of the difference in body weight between attackers and goalkeepers has not been shown. Our recorded values of lean body mass are consistent with absolute values of other available studies (Milanese et al., 2015; Milsom et al., 2015; Ostojic, 2003; Silvestre, West, Maresh, & Kraemer, 2006). Goalkeepers in 1st team of English premier league have significantly greater absolute amount of lean body mass than midfielders ($p \leq 0.05$). Goalkeepers of U18 have significantly greater absolute amount of lean body mass than midfielders and strikers ($p \leq 0.05$) (Milanese et al., 2015).

Components of lean body mass are very important in terms of monitoring changes at the cellular level. Intracellular mass is composed of all cells able to utilize oxygen, i.e. cells participating in the movement. The ECM/BCM ratio showed values recommended for elite sport in all monitored athletes (Dörhöfer & Pirlich, 2007). An insignificant difference indicates genetic determination of this parameter and its value as a predisposition for implementation of physical activities (Malá et al., 2014). Monitoring of lean body mass components (intracellular and extracellular mass), eventually total body water components (intracellular and extracellular water) is helpful in comparison of changes during a shorter period (short-term intervention, post-traumatic state, etc.), in which estimation of muscle mass, lean body mass and fat mass values does not have to change.

In our screened sample, midfielders are the shortest players and with the smallest amount of body fat (Table 2) as compared with the other positional roles. In comparison to attackers and defenders, midfielders cover far greater distances (Sporis et al., 2009). A significant difference in fat mass proportion was not found despite the fact that available literature presents that defenders had significantly more body fat ($p < 0.05$) than attackers and midfielders (Sporis et al. (2009). Wittich, Oliveri, Rotemberg, and Mautalen (2001) present 12 ± 3.1 % of fat mass on average (DEXA) in professional soccer players. The authors report significantly greater proportion of fat mass in midfielders than in backs or forwards ($p \leq 0.05$). Sutton et al. (2009) presents 10.6 ± 2.1 % of fat mass (English premier league, $n = 64$, 4 teams). Reilly et al. (2009) mentions 11.2 ± 1.8 % of fat mass (professional players, $n = 45$, English Premier League). Milsom et al. (2015) reported 10.0 % of fat mass in professional soccer players from one English Premier League soccer club ($n = 83$, U18, U21 and 1st Team) and significantly lower percentage of fat mass in 1st team in comparison to the other tested teams (U21 and U18), $p \leq 0.05$. When comparing our collected data, it is necessary to respect the different method used and calculation of indirectly measurable parameters. Eventual reduction of excess fat mass is the most effective using training and dietary protein intake and aerobic exercise (Langan-Evans, Close, & Morton, 2011; Morton, Robertson, Sutton, & MacLaren, 2010; Reilly et al., 2009).

Our recorded values of regional muscle mass are comparable with values in elite soccer players presented in the available literature (Milsom et al., 2015; Silvestre et al., 2006). When comparing regional muscle mass in all monitored segments, goalkeepers achieved significantly greater proportion in comparison to other field positions (Table 3). Silvestre et al. (2006) reported the highest values of leg lean tissue in fullbacks and goalkeepers in comparison to other field positions ($n=27$, Division I collegiate soccer players). Milsom et al. (2015) reported significantly greater proportion of lean body mass (kg) in all monitored segments (left arm, right arm, trunk, left leg, right leg) ($p \leq 0.05$) in the 1st team of English Premier League in comparison to U18 ($n = 75$). Significance also appeared in the dominant lower limb between U18 and U21 ($p \leq 0.05$). Significance of the difference in muscle mass proportion in the dominant and non-dominant leg in all field positions indicates the lower limb preference in activities such as passing and shooting in the training process. In case of detecting morphological asymmetry in elite players, it is essential to monitor the revealed differences and compensate

them in specific training. It is also needed to undergo other functional examinations, such as test of isokinetic strength of knee flexors and extensors and determining bilateral or ipsilateral ratio of strength parameters (Lehnert, Psotta, Chvojka, & De Ste Croix, 2014; Maly, Zahalka, & Mala, 2014; Malý, Zahálka, & Malá, 2010).

Conclusion

A player with optimal body morphology and body composition for all field positions does not exist. A certain limit in achieving high quality performance can be a low proportion of active mass and high proportion of fat mass or insufficiently flexible joints and shortened muscle groups when imbalance is observed. Research has shown differences between anthropometric indicators and body composition parameters in players on the basis of division according to their field positions. These differences can be considered when selecting talented youths (e.g. prediction of goalkeeper's body height). Monitoring body composition in soccer players is also important in terms of nutrition habits, changes of hydration and already mentioned parameters identifying body composition throughout the training process. Maladaptive effects in terms of different segmental muscle mass proportion between preferred and non-preferred leg may represent a potential risk of a player's injury; therefore the detected asymmetries should be systematically monitored and compensated using specific exercises. In terms of practice, the results may be beneficial for fitness coaches, physiotherapists, nutrition specialist, doctors and other clinical staff in professional soccer. Moreover, the collected data may serve for comparison in attempts at achieving optimal body composition for youth elite soccer players with respect to field position for players with lower performance level as a criterion to target "ideal values".

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